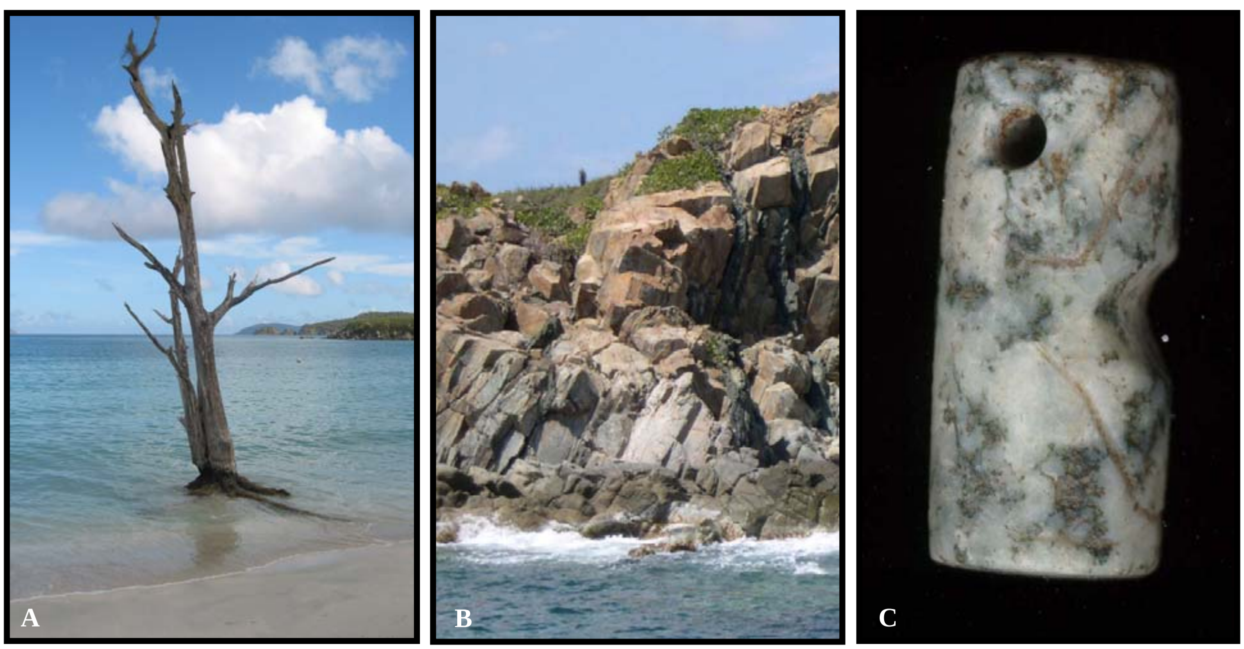
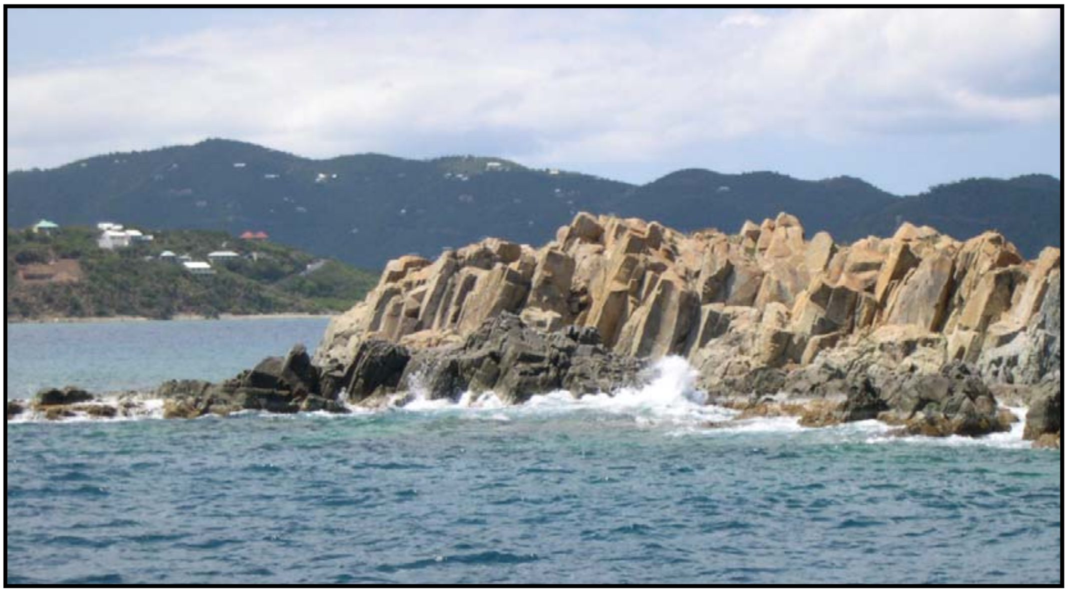
VIRGIN ISLANDS NATIONAL PARK
and
CORAL REEF NATIONAL MONUMENT

GEOLOGIC RESOURCE MANAGEMENT ISSUES
SCOPING SUMMARY



Kimberly N. Hall
Geologic Resource Evaluation
September 1, 2005



Columnar Jointing on LeDuck Island, USVI. The south shore of St. John is visible in the background.

Hydrothermal alteration in the Water Island Formation, south and central St. John, USVI.   The White Cliffs display mineral alteration including copper (green), iron (red), and limonite (yellow). Much of the white coloration is due to the large amount of plagioclase feldspar within the igneous rocks.

Title page:

A) Coastal Erosion at Cinnamon Bay. This Seaside Maho was once located in the protected backshore area of the beach. This tree (one of many) died due to continued seawater inundation and coastal erosion. Currently, many important archaeological sites at Cinnamon Bay are threatened due to beach erosion.
Photo: Jack Hopkins

B) Swarming dikes on Ditliff Point, south shore, St. John.

C) Marble Taino trading bead found on Cinnamon Bay, St. John.   Scientists question if this bead was created on St. John or imported from an alternate source. This problem demonstrates a clear link between archaeology and geology.

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EXECUTIVE SUMMARY

A Geologic Resources Evaluation scoping meeting for Virgin Islands National Park and Coral Reef National Monument was held at Park headquarters in Cruz Bay, VI on April 7-9, 2004. The scoping meeting participants identified the following as the most significant geologic resource management issues.

1. Minimize the effects of erosion and sedimentation into adjacent marine ecosystems due to land use and grazing.

2. Inventory and monitor coastal resources and processes including beach erosion/accretion due to storm events and recreational demands.

3. Inventory and monitor marine processes and resources such as sediment transport, sediment thickness, coral reef location, and human impacts on benthic habitats.

4. Monitor the possible effects of windblown particulates (i.e. Saharan dust, Monserrat dust) on park resources.

INTRODUCTION

The National Park Service conducted a Geologic Resources Evaluation scooping meeting at Virgin Islands National Park, St. John, USVI, April 7-9, 2004. The purpose of the meeting was to discuss the status of geologic mapping in the park, the associated bibliography, and the geologic issues in the park. The products to be derived from the scoping meeting are: (1) Digitized geologic maps covering the park; (2) An updated and verified bibliography; (3) Scoping summary (this report); and (4) A Geologic Resource Evaluation Report which brings together all of these products.

Virgin Islands National Park (VIIS) was established August 2, 1956, and was declared a Biosphere Reserve by the United Nations in 1976. The park includes slightly more than half of the island of St. John and approximately nine square miles of the surrounding waters. In addition, Virgin Islands National Park includes land in Red Hook, St. Thomas (6 acres), Wintberg Estate, St. Thomas (4 acres), and Hassel Island (135 acres). The total area of VIIS is currently 14,689 acres (FY-2004).

Coral Reef National Monument (CRNM) was established by President Clinton on January 17, 2001 to protect and preserve the delicate coral resources contained within. This monument contains 12,708 acres of submerged lands adjacent to St. John including Hurricane Hole.

VIIS MAPPING PRODUCTS

Virgin Islands National Park has “quadrangles of interest” (or “QOI’s”) at the 7.5’x7.5’- *(1:24,000) scale.* It is desired to obtain DIGITAL geologic map coverage for all identified 7.5’ qoi’s..

The contents of this document reflect what is known regarding published geology as of September 6, 2005 from searches done by NPS-GRD staff as discerned from the USGS on-line geologic maps database found at
http://ngmdb.usgs.gov/ngmdb/ngm_compsearch.html

All comments and suggestions to improve this understanding are most welcome at this time and will be summarized in a summary report following from this meeting.

Virgin Islands National Park is covered by the following publications:

- *Rankin, D.W., 2002, Geology of St. John, U.S. Virgin Islands, US Geological Survey, Professional Paper 1631, 1:24000 scale*

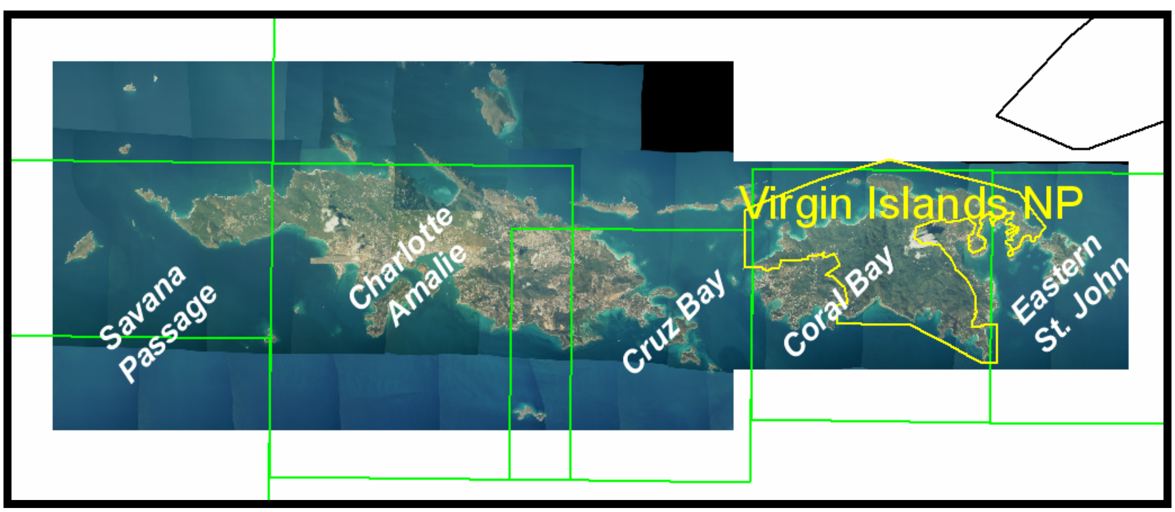
- NOAA Benthic Habitats map

During the scoping sessions held in April 2004 for VIIS, it was decided that the Rankin map would be the best available source to give the bedrock geology of the island of Saint

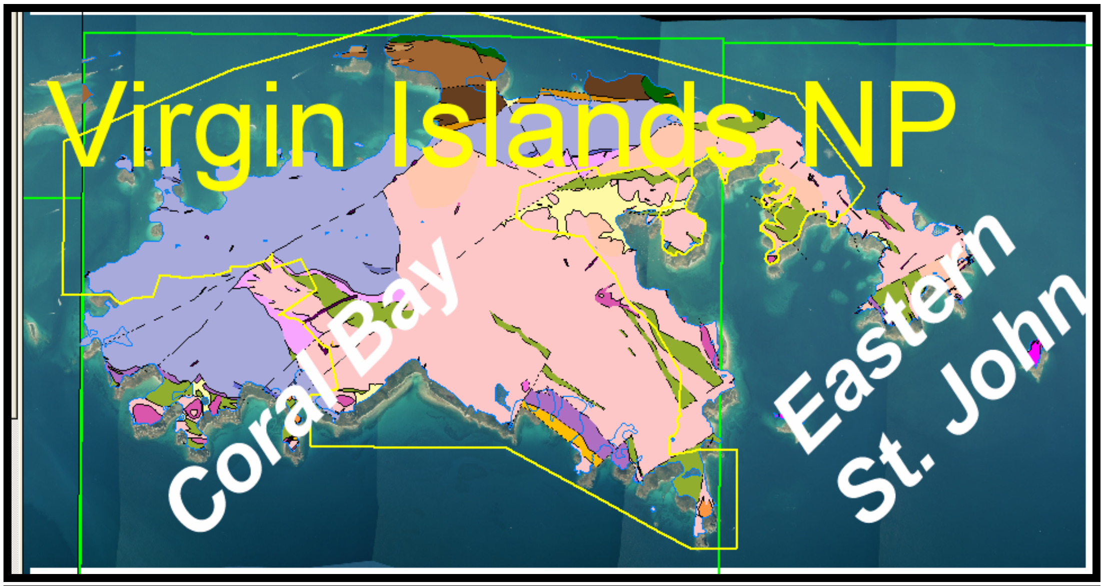
John. NPS-GRE staff acquired the original paper map and converted it into a digital user-friendly GIS product that is available on-line at http://science.nature.nps.gov/nrdata/

The NOAA benthic habitat maps will accompany the bedrock map of the island and is already available digitally. NPS-GRE staff will incorporate it as well into a final geologic map of the island. A summary table follows along with explanatory graphics.

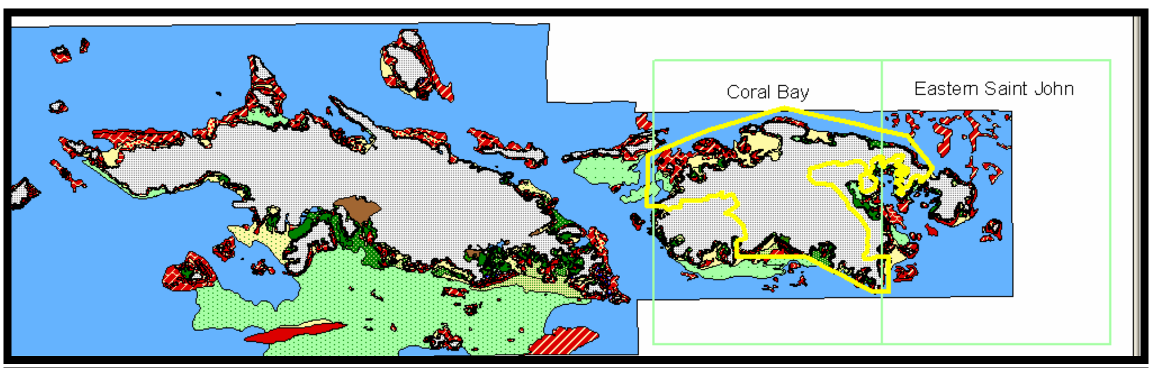
Extent of Coverage	Published Map Citation	Paper	Digital	GRE Plan
Entire island of Saint John	Rankin, D.W., 2002, Geology of St. John, U.S. Virgin Islands, US Geological Survey, Professional Paper 1631, 1:24000 scale	yes	Yes	GRE already have digitized this map
Entire islands of Saint John and Saint Thomas	Kendall, M.S., M.E. Monaco, K.R. Buja, J.D. Christensen, C.R. Kruer, and M. Finkbeiner, R.A. Warner, 1999, Benthic Habitat and Zone Maps of St. Thomas and St. John, U.S. Virgin Islands; Prepared by Visual Interpretation from Remote Sensing Imagery Collected by NOAA in 1999, , , 1:6000 scale	Unknown	Yes, from NOAA	Convert NOAA digital version to NPS format



Quadrangles of Interest (QOI's) for VIIS (7.5' shown in light green outline; park boundaries in yellow outline; MrSID image of Islands of Saint John and Saint Thomas as background)



Extent of Rankin, D.W., 2002, Geology of St. John, U.S. Virgin Islands, US Geological Survey, Professional Paper 1631, 1:24000 scale



NOAA Benthic Habitats of St John and St Thomas.

GEOLOGY AND STRATIGRAPHY OF ST. JOHN, USVI

The geologic history of St. John began in the Early Cretaceous (~100mya) with the shallow water deposition of the *Water Island Formation*. This unit is composed predominantly of extrusive keratophyres (fine-grained igneous rocks with high Si and K content), basalts, and minor cherts that formed in an extensional oceanic environment (Rankin, 2002). This formation was produced from the same volcanism that formed the Greater Antilles. The Water Island Formation is the oldest unit found on St. John, with exceptional exposures on the south side of the island. The unit is estimated to be at least two kilometers thick (Rankin, 2002), and although the base is not visible, it is presumed to be underlain by oceanic crust (Donnelly, 1989).

Geologic features commonly found within the Water Island Formation include pillow basalts, volcanic wackes and tuffs, amygdaloidal basalts, and nodular keratophyres. Internal stratigraphic order has not been observed, although the "attitude of these contacts, along with bedding in the volcanic wacke, flow layering in keratophyres (used cautiously), and "bedding" in pillowed basalt aid in defining the map pattern and overall structure" of the formation (Rankin, 2002). Due to mixed masses of keratophyres and basalts, it is possible that two lava types were extruded concurrently (Rankin 2002).

Intrusive rocks of the *Careen Hill Intrusive Suite* are commonly found within the Water Island Formation. The igneous intrusions are primarily the intrusive equivalents of the Water Island Formation. Small dikes and plutons composed of intrusive keratophyres and fine-grained gabbros are found interspersed throughout the Water Island formation. Spectacular features found within the Careen Hill Intrusive Suite include columnar jointing and sheeted dikes. The columnar jointing found on Leduck island is composed of the whitish granite, Trondhjemite. The Water Island Formation and the Careen Hill Intrusive Suite combine to form the *Lameshur Volcanic-Intrusive Complex* (Rankin, 2002).

The Lameshur Volcanic-Intrusive Complex is overlain by more than 1.5km of blue andesite ash beds and pyroclastic breccias called the *Louisenhoj* formation. This unit was formed in the Late Cretaceous when explosive subduction-related volcanism occurred in shallow marine waters associated with a developing island arc environment. Graded bedding is evident throughout the formation due to the deposition of volcanic material by submarine slides and slumps. A variety of clast sizes suggest that numerous volcanic vents are located nearby. Geologic features found throughout the Louisenhoj formation include volcanic conglomerates and wackes, andesite tuff breccias, and bedded, boulder volcanic conglomerates. The Louisenhoj formation covers the Western half of Saint John, including Cruz Bay and Rendezvous Bay. It is commonly referred to as "Blue Bitch" rock by Saint Johnians.

Following the deposition of the Louisenhoj formation, St. John experienced a period of reduced volcanism and gradual sea floor subsidence. At that time (L. Cretaceous), approximately 100m of thinly bedded limestone, referred to as the *Outer Brass Limestone,* was deposited in a quiet marine environment. It is thought that deposition occurred on moderate slopes a few hundred feet in depth. This formation contains high concentrations of silica tests and thin, interbedded tuffs. Due to contact metamorphism from Tertiary plutons, deposits of white and blue-gray calcitic marble containing plagioclase, epidote, garnets, diopside, vesuviatnite, and wollastonite are found throughout the formation (Rankin, 2002). This unit forms a discontinuous belt extending from Maho Bay to Brown Bay, with excellent exposures at Mary's Creek on the north shore of the island. It is possible this marble was utilized by native Taino peoples for trading beads and jewelry.

Although the Outer Brass Limestone is a thin, minor unit on St. John, it is a useful tool for separating the conglomeratic Louisenhoj formation from the lesser conglomeratic *Tutu formation* (Rankin, 2002). The Tutu Formation formed when island arc volcanism resumed in the Late Cretaceous. Most of the material seems to have been deposited by turbidity currents, suggesting deposition on an "unstable slope such as a trench wall leading into an accretionary wedge (Rankin, 2002)."

The Tutu Formation extends from Maho Bay to Leinster Point. This formation is characterized by volcanic wackes, shales, conglomerates, calcareous siltstones, limestones, and rare basalts and andesites (or their metamorphic equivalents) (Rankin, 2002). Volcaniclastic fragments found within the Tutu formation are generally sand and silt size suggesting the volcanic source was further away than the Louisenhoj vents (Rankin, 2002). Additionally, a distinct fining-upward implies increasingly distant volcanic sources. The extrusive igneous rocks of the Tutu formation are the last evidence of volcanism on St. John.

The Tertiary period was marked by intense plutonic activity that produced folding and faulting across the island. Following the intrusion of diabase dikes, north-south compression was created by the collision of the Caribbean plate and the North American plate. The intensity of deformation increases northward on St. John.

The last period of tectonic activity on the island occurred after the late Eocene (post 39 mya). At that time a series of strike slip faults occurred due to the spreading of the Cayman Trough. No recent tectonic activity has been recorded.

SIGNIFICANT MANAGEMENT ISSUES

The scoping participants identified the following as the most significant geologic issues at Virgin Islands National Park:

1. Slope stability and erosion

St. John is characterized by rugged terrain with steep, rocky slopes. More than 80% of the island is covered with hillsides in excess of 30% (CH2M Hill, 1979). Slope failure is common during storm events and may have devastating effects on terrestrial, coastal, and marine habitats. Recently, numerous nesting sites of the endangered brown pelican were decimated due to slope instability caused by Tropical Storm Frances (2002). In addition, roads are often impassable during storm events due to rock and mudslides, creating serious hazards to park visitors.

Grazing is another cause of slope failure within the park. Feral goats and hogs negatively impact fragile park resources. Heavy grazing on steep hillsides increase erosion into adjacent coastal and marine ecosystems. Even small increases in sedimentation may have devastating effects on fragile environments including coral reefs and seagrass beds.

2. Coastal Processes

Virgin Islands National Park is known for its beautiful beaches and unique coastal ecosystems. Many of the park's management issues concern the protection and preservation of these valuable resources. Unfortunately, many of these resources are at risk due visitor demands, anthropogenic modifications, and/or natural coastal dynamics. Immediate concerns include, but are not limited to, the following:

1. <u>Beach erosion</u> - Cinnamon Bay contains one of the beaches experiencing rapid erosion in Virgin Islands National Park. This popular tourist beach is the site of numerous archaeological sites, some dating to 900AD. The Archaeology Center, the oldest remaining active structure on St. John, is at great risk for destruction. Riprap was placed along the shoreline in the 1970's to slow beach erosion. However, this has done little to diminish destructive processes. The loss of shoreline vegetation is an additional management concern associated with beach erosion.

2. <u>Coastal development</u> – coastal development on St. John continues to increase at an alarming rate. Construction increases sedimentation rates into adjacent waters. Sedimentation and runoff may damage fragile marine ecosystems including coral reefs and seagrass beds. Water quality monitoring is performed monthly at numerous locations throughout the park to assess damage from coastal development.

3. <u>Anthropogenic modifications</u> – Modifications have been made to some of St. John's shorelines. For example, docks have been constructed at Lameshur,

Caneel, and Cruz Bays. Also, as previously mentioned, the Archaeology Center at Cinnamon Bay is protected by riprap. Any shoreline change will affect shoreline dynamics. Changes in sediment transport, including beach erosion and accretion should be closely monitored where human structures have been erected.

Dredging is an another concern to park managers. Dredging is often performed in Cruz Bay to benefit shipping, transport and recreation. Coastal dredging increases turbidity and sediment loads, thereby damaging marine resources. Dredging may also interfere with sediment transport and flow dynamics in coastal and marine systems. In addition, dredged sediments may include harmful contaminants and pollutants.

4. Salt pond infilling – the salt ponds found within Virgin Islands National Park are in danger of infilling due to increased sediment loading. High sedimentation rates may be caused by a variety of factors including feral animal grazing, storm events, and/or human activities.

3. Marine Processes

1. Sediment characteristics – sediment thickness, type, and grain size should be integrated into park maps. Available information on sediment distribution, budget, and sources and sinks should be available to park managers for a variety of reasons including, but not limited to, buoy placement and maintenance, boat anchoring, and erosion hotspots. An understanding of the system's sediment supply is critical for monitoring coastal areas and predicting shoreline change (Nelson, 2002).

2. Recreation Impacts –More than 800,000 guests visit the park each year. Common forms of recreation include boating and fishing- both of which may have detrimental impacts on park resources. Two of the most serious impacts defined at this meeting include the following:

   A. Boating – anchoring and vessel groundings have seriously damaged many coral reefs, seagrass beds, and mangrove forests in VIIS and CRNM. Although anchoring is permissible in certain areas, illegal anchoring and anchor dragging (usually due to ignorance) has destroyed marine habitat throughout the park. In addition, vessel groundings due to inexperienced boating and storm events have critically damaged large sections of coral reefs.
   B. Surfing – Surfing occurs at many locations in the park including Johnson's Reef, Fish Bay, and Cinnamon Bay. Surfing hazards include dangers to both park visitors and park resources. For example, surfing at Johnson's Reef may damage fragile coral habitat.

In addition, park visitors have been gravely injured while body surfing at Cinnamon Bay due to the steep break at the shoreline. However, the beaches must remain open due to the Free Beach act.

3. Oceanographic Variables – Relative sea level rise, temperature and salinity patterns, currents, and tidal regimes should be monitored for Virgin Islands National Park. These variables may aid in identifying sediment transport patterns within the park. In addition, knowledge of currents at headlands and in channels may reduce visitor injuries.

4. Benthic habitat mapping – Virgin Islands National Park is working in cooperation with NOAA to complete benthic habitat mapping for the park. Benthic habitats including coral reefs and submerged aquatic vegetation should be included in coastal mapping products. These features influence the hydrodynamic regimes within their localized areas, thereby determining sedimentation patterns. The location of marine habitats should be known in order to determine the impacts that coastal development and visitor use may have on their health and survival (Nelson, 2002).

4. Windblown Features and Processes

Currently, the park is investigating the effects of Saharan dust on park resources. It is believed that imported particulates could have harmful effects on fragile marine habitats such as coral reefs and seagrass beds, by carrying fungi and dust-borne pathogens. Dust from alternate sources such as the Montserrat eruption of 1995 could also have negative impacts on park resources.

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